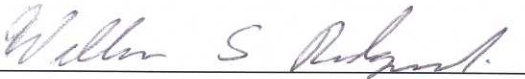
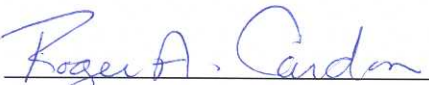
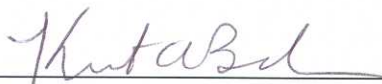
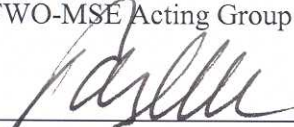


## CRITERION 402

## WATER TREATMENT OF OPEN COOLING UNITS

## SIGNATURES

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1	06/24/03	Format revised to adhere to Operations & Maintenance (O&M) Criterion 101-Writer's Guide, Revision 3 Addition of Basis and References  Addition in Precautions and Limitation Section to address Molybdenum and Molybdate Change all reference of DOE O 4331.4B to new DOE O 433.1

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## **CRITERION 402**

### **WATER TREATMENT OF OPEN COOLING UNITS**

#### **1.0 PURPOSE**

The purpose of this Criterion is to establish the minimum requirements and best practices for operation and maintenance of water treatment for 03A permitted open cooling units as well as cooling units discharging to the TA-46 Sanitary Waste Water (SWWS).

This document addresses the requirements of LIR 230-05-01(Ref 10.1), "Operations and Maintenance Manual."

Implementation of this Criterion satisfies DOE Order 430.1A (Ref 10.2) for the subject equipment / system. DOE Order 430.1A (Ref 10.2) "Life Cycle Asset Management," Attachment 2 "Contractor Requirements Document," Paragraph 2, Sections A through C, which in part requires UC to "...maintain physical assets in a condition suitable for their intended purpose," and employ "preventive, predictive, and corrective maintenance to ensure physical asset availability for planned use and/or proper disposition." Compliance with DOE Order 430.1A is required by Appendix G of the UC Contract.

#### **2.0 SCOPE**

The scope of this Criterion is the testing and treatment of open cooling water in open cooling systems. This includes air washers, chiller-water evaporative units (CWE), condenser-refrigerant evaporative units (CRE), and cooling towers. This Criterion does not address corrective maintenance actions required to repair or replace equipment.

#### **3.0 ACRONYMS AND DEFINITIONS**

##### **3.1 Acronyms**

<b>AHJ</b>	Authority Having Jurisdiction
<b>BTU</b>	British Thermal Unit
<b>CFR</b>	Code of Federal Regulations
<b>CRE</b>	Condenser Refrigerant Evaporative
<b>CWE</b>	Chiller-Water Evaporative
<b>DOE</b>	Department of Energy

<b>EPA</b>	Environmental Protection Agency
<b>FM</b>	Facility Manager
<b>FMU</b>	Facility Management Unit
<b>FWO</b>	Facility Waste Operations
<b>LANL</b>	Los Alamos National Laboratory
<b>LIG</b>	Laboratory Implementing Guidance
<b>LIR</b>	Laboratory Implementing Requirement
<b>LPR</b>	Laboratory Performance Requirement
<b>MSE</b>	Maintenance and System Engineers
<b>MSDS</b>	Material Safety Data Sheet
<b>NMED</b>	New Mexico Environmental Department
<b>NPDES</b>	National Pollutant Discharge Elimination System
<b>O&amp;M</b>	Operations and Maintenance
<b>PPE</b>	Personal Protective Equipment
<b>PPM</b>	Parts Per Million
<b>PP&amp;PE</b>	Personal Property and Programmatic Equipment
<b>RP&amp;IE</b>	Real Property and Installed Equipment
<b>RRES-WQH</b>	Risk Reduction and Environmental Stewardship – Water Quality and Hydrology
<b>SAR</b>	Safety Analysis Report
<b>SiO<sub>2</sub></b>	Silicon Dioxide (generically referred to as Silica)
<b>SSC</b>	Structures, Systems, and Components
<b>SSS</b>	LANL's Support Services Contractor
<b>SWSC</b>	Sanitary Wastewater System Consolidation
<b>SWWS</b>	Sanitary Waste Water System
<b>TSR</b>	Technical Safety Requirements
<b>UC</b>	University of California
<b>WAC</b>	Waste Acceptance Criteria
<b>WPF</b>	Waste Profile Form

### 3.2 Definitions

**Air Washers.** These units filter and cool air (cool by evaporation). They are located within building ventilation systems. Air washers usually have a water basin, a circulating pump, spray nozzles and plastic or cellulose media. Some units simply spray water into a chamber. Air washers have scale inhibiting chemicals and controllers to limit the cycles of concentration. Chlorine compounds are not used in the air washers. A quaternary ammonium compound is used to control bacterial buildup. Other biocides, if compatible with breathing air, may be selected.

**Algae.** Form of plant life, which generally requires sunlight and air for existence. Causes plugging of heat exchanger tubes and cooling tower distribution systems.

**Ammonium Bifluoride.** A chemical used to dissolve silica scale from heat exchangers. Used with an inhibitor (Rodine 103) and hydrochloric acid.

**Biocide.** Chemical used to control algae growth in cooling towers and/or bacteria in air washers. A chlorine-bromine compound is used in cooling towers and a quaternary ammonium tablet is used in air washer systems.

**Blowdown.** Water discharged from a cooling system to control the concentration of salts or other impurities in the circulating water.

**Brominator.** Chemical feed device that introduces bromine into water stream for control of algae and bacteria.

**Cooler-Water Evaporative (CWE).** Uses water and air to cool process water in a fin tube coil. As in the condenser-refrigerant evaporative, water is pumped from the base of the unit and sprayed over the coil. Air is forced across the coil by a fan. Scale and corrosion inhibitors are used in these units. Chlorine-bromine chemicals are used if required for algae and slime control. Cycles of concentration are controlled by blowdown.

**Condenser-Refrigerant Evaporative (CRE).** Uses water and air to condense refrigerant vapor. Vapor is contained in a fin tube coil and water is pumped from basin of unit to spray nozzles over the coil. Heat is rejected from hotter refrigerant into water (evaporates water) air is forced (or induced) across the coils by a fan. These units use scale and corrosion inhibiting chemicals and may require a chlorine-bromine chemical for algae or slime control. They have blowdown controls to limit cycles of concentration.

**Conductivity.** Measurement of ionizable solids in solution expressed in micromhos/cm or microsiemens/cm. Ratio of makeup water conductivity to cooling unit water conductivity can control cycles of concentration.

**Cooler-Air Evaporative.** These units are the "swamp coolers" located on the roof of most transportables and trailers. No scale inhibitor chemicals are used and there is no blowdown during operations. The cooler pads are replaced once/year and a quaternary ammonium compound is added for bacteria control.

**Cooling Towers.** A device for the evaporative cooling of water by contact with air. Cools by exchange of latent heat resulting from evaporation (approximate 1000 BTU per pound of water evaporated) and by transfer of sensible heat to air. LANL towers use fans to force or induce the flow of air across (Cross Flow) or against (Counter Flow) the flow of water for evaporation. Cooling towers use scale and corrosion inhibitors and chlorine-bromine chemicals for algae and slime control. Cooling towers that discharge to 03A outfalls must be equipped with a de-chlorination system. All towers have controls to limit cycles of concentration. Cold tower water is used in heat exchangers or condensers for process water-cooling.

**Cycles of Concentration.** The ratio of the volume of makeup water to the volume of blowdown water, over a period of time. The cycles of concentration can be used to compare the concentration of dissolved solids in the circulating water to the concentration of dissolved solids in the makeup water.

**De-chlorination.** The removal of chlorine from water.

**Make-Up.** Water added to the circulating water system to replace water lost by evaporation, drift, blowdown, and leakage.

**National Pollutant Discharge Elimination System (NPDES).** - The national program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits to discharge wastewater or storm water, and imposing and enforcing pretreatment requirements under the Clean Water Act.

**Outfall.** Point at which a permitted discharge from an open cooling unit enters the environment.

**Water Treatment.** Application of chemicals to treat cooling water for scale, corrosion, and biological growth.

## 4.0 RESPONSIBILITIES

### 4.1 FWO- Maintenance and System Engineering (MSE)

- 4.1.1 FWO-MSE is responsible for the technical content of this Criterion and monitoring the applicability and the implementation status of this Criteria and either assisting the organizations that are not applying or meeting the implementation expectations contained herein or elevating their concerns to the director(s).

*Basis:* LIR 301-00-01.11; Issuing and Managing Laboratory Operations Implementation Requirements and Guidance, Section 5.4, OIC Implementation Requirements.

- 4.1.2 FWO-MSE shall provide technical assistance to support implementation of this Criterion.

**4.2 Facility Manager**

**4.2.1** Responsible for operations and maintenance of institutional, or Real Property and Installed Equipment (RP&IE) under their jurisdiction, in accordance with the requirements of this document.

**4.2.2** Responsible for operations and maintenance of those Personal Property and Programmatic Equipment (PP&PE) systems and equipment addressed by this document that may be assigned to the FM in accordance with the FMU-specific Facility/Tenant Agreement.

**4.3 Group Leader**

**4.3.1** Responsible for operations and maintenance of those Personal Property and Programmatic Equipment (PP&PE) systems and equipment addressed by this document that are under their jurisdiction

**4.3.2** Responsible for system performance analysis and subsequent replacement or refurbishment of assigned PP&PE.

**4.4 RRES - Water Quality and Hydrology**

**4.4.1** Sample 03A Outfalls in accordance with NPDES requirements. Use analytical results to verify compliance. RRES-WQH is also responsible for submittal of all compliance data to the U.S., EPA and NMED as required for NPDES permit. RRES-WQH approves all chemical formulations used in water treatment.

**4.5 Authority Having Jurisdiction (AHJ) – RRES-WQH**

**4.5.1** The AHJ is responsible for providing a decision on a specific technical question regarding national, state and local codes and DOE orders.

**5.0 PRECAUTIONS AND LIMITATIONS****5.1 Precautions**

This section is not intended to identify all applicable precautions necessary for implementation of this Criterion. A compilation of all applicable precautions shall be contained in the implementing procedure(s) or work control authorization documents. The following precautions are intended only to assist the author of a procedure or work control document in the identification of hazards and precautions that may not be immediately obvious.

Nuclear facilities and certain other facilities (e.g., high hazard, high explosive operations) may have additional facility specific requirements beyond those presented



in this Criterion which are contained in the Safety Analysis Report (SAR), Technical Safety Requirements (TSR), or facility safety plans, as applicable. Comply with NPDES Permit No. NM0028355. Comply with 03A O&M Manual.

- 5.1.1** Any outfall measurement made with an EPA approved method must be reported to RRES-WQH.
- 5.1.2** Molybdenum and Molybdate compounds (sodium Molybdate is used as a test tracer and corrosion inhibitor in scale treatment chemicals) are no longer allowed by RRES-WQH to be discharged without a ground water discharge plan.

*Basis:* 20.6.2 3000 NMAC, Permitting and Ground Water Standards (Ref 10.14)

- 5.1.3** Cooling tower fans are temperature controlled and may start at anytime.
- 5.1.4** Cooling tower environments can be very wet and slippery. In winter, slip hazards can greatly increase with freezing.
- 5.1.5** All new cooling units discharging to SWWS need to fill out a Waste Profile Form (WPF). All cooling units exceeding the SWWS Waste Acceptance Criteria (WAC) must submit WPF and request waiver for SWWS-WAC requirements.

## **5.2 Limitations**

The intent of this Criterion is to identify the minimum generic requirements and recommendations for SSC operation and maintenance across the Laboratory. Each user is responsible for the identification and implementation of additional facility specific requirements and recommendations based on their authorization basis and unique equipment and conditions, (e.g., equipment history, manufacturer warranties, operating environment, vendor O&M requirements and guidance, etc.).

Nuclear facilities and moderate to high hazard non-nuclear facilities will typically have additional facility-specific requirements beyond those presented in this Criterion. Nuclear facilities shall implement the requirements of DOE Order 433.1 (Ref. 10.3) (or 10 CFR 830.340, Maintenance Management, when issued) as the minimum programmatic requirements for a maintenance program. Additional requirements and recommendations for SSC operation and maintenance may be necessary to fully comply with the current DOE Order or CFR identified above.

## **6.0 REQUIREMENTS**

Minimum requirements that Criterion users shall follow are specified in this section. Requested variances to these requirements shall be prepared and submitted to FWO-MSE in accordance with LIR 301-00-02 (Ref. 10.4), "Variances and Exceptions to

Laboratory Operations Requirements,” for review and approval. The Criterion users are responsible for analysis of operational performance and SSC replacement or refurbishment based on this analysis. Laws, codes, contractual requirements, engineering judgment, safety matters, and operations and maintenance experience drive the requirements contained in this section.

## **6.1 Operations Requirements**

### **6.2 General**

- 6.2.1** The permittee/operator shall at all times, properly operate and maintain the cooling system as efficiently as possible and in a manner which will achieve compliance with the conditions of the permit.

*Basis:* NPDES permit No. NM0028355 Part III 13-B.3, Feb. 2, 2001 (Ref 10.9)

- 6.2.2** The minimum times provided in this criterion for testing, inspection, and maintenance of operating units, and checking conductivity controllers, have been established based on experience of what achieves compliance with the conditions of the Laboratory’s permit. If the Facility Manager or Group Leader feel that a frequency below the minimum established, within this criterion, will provide compliance with the Laboratory’s NPDES permit, RRES-WQH shall be contacted for review and concurrence. A formal justification and basis shall be prepared and submitted as part of a variance request in accordance with LIR 301-00-02.

### **6.3 Selection of Treatment Chemicals**

- 6.3.1** Chemical formulations used in water treatment require RRES-WQH approval.

*Basis:* LIR 404-50-01.1 Water Control Pollution (Ref 10.8)

### **6.4 Testing**

- 6.4.1** All operating cooling units shall have the circulating cooling water tested at the following minimum frequencies:
- Cooling Towers once/week
  - Chillers-Water Evaporative once/week
  - Condensers -Refrigerant Evaporative once/week
  - Air Washers every other week
  - Swamp Coolers (Coolers-Air Evaporative) no testing required
  - Where applicable, tests shall include conductivity, treatment chemical concentration, and chlorine. Tests for hardness, silica, P04 and pH may also be utilized.

- Test methods for operational sampling may follow HACH Water Analysis Handbook and DR/2000/Spectrophotometer Handbook. These, or alternate, tests must be verified regularly with direct calibration. (Ref 10.6 and Ref 10.7)
- Operational samples must be collected out of basin or circulated water at specific sampling parts designed into the system and not at the outfall.

*Basis:* NPDES permit No. NM0028355 Part III 13-3 (Ref 10.9)

## **6.5 Checking Controllers**

- 6.5.1** Conductivity controllers must be checked/calibrated for proper operation once/week.

*Basis:* NPDES permit No. NM0028355 Part III 13-B.3, Feb. 2, 2001 (Ref 10.9)

## **6.6 Biocide Treatment**

- 6.6.1** Cooling units that discharge into NPDES permitted outfalls have a chlorine discharge limitation of 11 ug/L average and 11 ug/L maximum (.011 ppm or 11 parts per billion).

*Basis:* NPDES permit No. NM0028355 Part III 13-3 (Ref 10.9)

- 6.6.2** Chlorine may be applied to the units as a white tablet that slowly dissolves to release chlorine and bromine. Release rate is controlled by a brominator (pot feeder) with flow control valves or by placing tablets in a mesh bag. Mesh bags are placed in water flow within tower fill, not in tower basin.

## **6.7 Inspections**

At minimum, perform the following checks weekly for operating cooling towers, condensers-refrigerant evaporative, chillers-water evaporative, and every other week for operating air washers:

- A. Water leaks, broken water lines.
- B. Excessive algae growth on decks or fill.
- C. Plugged nozzles.
- D. Blowdown operation.
- E. Chemical feed pump(s) operation.
- F. Plugged or fouled screens.
- G. Basin water levels.
- H. Open doors or hatches.
- I. Unusual noise or vibration from fans or pumps.
- J. Leaking gearboxes or fans.

*Basis:* NPDES permit No. NM0028355 Part III 13-B.3, Feb. 2, 2001 (Ref 10.9)

## **6.8 Maintenance Requirements**

### **6.9 Required maintenance (minimum of once/week) on these units is:**

- Measure basin chlorine level.
- Check de-chlorination pump operation and setting and compare to previous log entry.
- Check level of dechlorination chemical and refill if necessary.
- Check for tablets in brominator and/or in bags.
- Check flow through brominator and/or location of mesh bags.

*Basis:* NPDES permit No. NM0028355 Part III 13-3 (Ref 10.9)

If outfall readings are over .011 ppm immediately shut off blowdown, reduce flow on brominator, remove tablets in bags, check dechlorination equipment and de-chlorinate basin until chlorine level is below .011 ppm.

#### **6.9.1** If necessary to shock treat a unit because of excess algae/microorganisms:

- A. Treat during a low load period if possible.
- B. Blowdown tower prior to treatment and turn off blowdown. Notify RRES-WQH before blowing down tower.
  - Add sufficient tablets to produce over 10-ppm chlorine. Insure blowdown is off.
  - Upon resumption of tower operation check basin. De-chlorinate if above 0.11 ppm. Restore automatic blowdown.

**Note:** Chemicals used for dechlorination will increase the conductivity of the basin. Take increased conductivity into account when calibrating controllers.

It is recommended that air washers and swamp coolers (coolers-air evaporative) use 20% quaternary ammonium for microorganism control. Plastic pouches containing biocide (1 for every 2 square feet of basin area) are placed in the basins upon start up of the units and are replenished every 3 months. Other biocides, if compatible with breathing air, may be used.

*Basis:* NPDES permit No. NM0028355 Part III 13-3 (Ref 10.9)

## **6.10 Scale and Corrosion Treatment**

A scale and corrosion inhibitor is added to open cooling systems. Concentration is measured according to manufacturer recommendations. Each cooling unit must be independently monitored and adjusted, as chemical delivery rates will differ.

### **6.10.1** Required maintenance for the scale and corrosion control is performed in the following manner:

- Every chemical container must be labeled and have an attached MSDS sheet.
- Measure the amount of treatment chemical in the circulating water and adjust if necessary.
- Record chemical levels and pump settings on log sheet.
- Record make-up and blowdown meter readings.

*Basis:* NPDES permit No. NM0028355 Part III 13-B.3, Feb. 2, 2001 (Ref 10.9)

## **6.11 Cleaning Operations**

Cleaning operations for closed and open cooling systems must follow procedures in the O&M Manual for 03A category outfalls.

**Note:** Cleaning operations performed on units with a 03A permitted outfall require 48-hour prior notice to RRES-WQH.

Cleaning operations on units discharging to sanitary require 24-hour notice to SWSC Plant Supervisor to prevent potential upsets. RRES-WQH must be notified immediately of any upset conditions or non-compliance conditions noted during O&M inspections or repair activities. Cooling tower solids must be disposed in accordance with Laboratory Requirements LIR 404-04.2.

Cleaning frequencies are as follows:

- Chiller Condensers - as necessary
- Heat Exchangers - as necessary
- Air Washers - yearly
- Chillers-Water Evaporative - yearly
- Condensers- Refrigerant Evaporative - yearly
- Cooling Towers – yearly

*Basis:* NPDES permit No. NM0028355 Part III 13-3 (Ref 10.9)

## **7.0 RECOMMENDATIONS AND GOOD PRACTICES**

The information provided in this section is recommended based on acceptable industry practices and should be implemented by each user based on his / her unique application and operating history of the subject systems / equipment.

### **7.1 Operations Recommendations**

LANL water is from volcanic formations and high in silica (SiO<sub>2</sub>). Analysis has shown that approximately 9% of the silica is polymeric and the remaining is nearly

monomeric. The maximum solubility of silica is in the range of 190 ppm in its native pH range. As the  $\text{SiO}_2$  concentration is increased from evaporation, polymerization occurs and silica particles precipitate from solution. When silica precipitates from solution, it readily forms scale on heat exchanger surfaces. For LANL, silica loading is the primary water problem.

For maximum efficiency, circulating water systems require scale inhibitors specific for silica.

*Basis:* LA- 1371, "The Management of Silica in Los Alamos National Laboratory Tap Water" (Ref 10.12)

- 7.1.1** Water use, for cooling towers at LANL, constitutes 58% of the total demand. Cooling tower water use has been inefficient since towers have been operated at approximately two cycles of concentration (Blowdown rate equals evaporation rate). A pilot study conducted in 2000 demonstrated the ability to run towers (with proper chemical treatment) at three cycles of concentration.

*Basis:* Los Alamos National Laboratory Cooling Tower Water Conservation Pilot Study (Ref 10.13)

## 7.2 Maintenance Recommendations

Chemical treatment and limiting cycles of concentration have been the historic methods at LANL for controlling silica scale.

Cleaning with Ammonium Bifluoride solution (12% by weight) has been the most successful method of cleaning silica scale from heat exchangers. There have been limited successes with cleaning some CRE and CWE systems utilizing sulfamic acid (1.25% by weight solution) and long (48 hours) circulating times.

**Note:** Disposal of cleaning solutions containing ammonium bifluoride and/or sulfamic acid cannot be discharged to SWWS without an approved WPF.

Rohm and Haas Company has developed a polymer called Acumer 5000, which is specific for silica control. They claim scale control at 300-ppm silica (about 3 cycles of concentration for LANL water). Most chemical suppliers will include Acumer 5000 in their formulations if requested.

- 7.2.1** Know the chemical make-up of the water you are treating.
- 7.2.2** Know the outfall location and NPDES permit Limitations.
- 7.2.3** Utilize the operations and maintenance manual for EPA Category 03A Outfalls. (Ref 10.10)

- 7.2.4** SSS Craftsperson must comply with PMI 44-40-004 Cooling Unit Maintenance and Water Treatment Manual. (Ref 9-11)
- 7.2.5** Operational samples must be collected in cooling tower basin(s) or at specific sampling parts designed into the system. Do not collect operational samples at the outfall.
- 7.2.6** Dedicate the operational responsibility to a single person. Have that individual keep a log, monitor the chemicals and cycles of concentration, inspect the system, and document changes. Maintaining a water/chemical balance through frequent testing and inspections is a key determinant to successful scale prevention.

*Basis:* Engineering Experience with LANL Cooling Systems Operations

## **8.0 GUIDANCE**

### **8.1 Operations Guidance**

- 8.1.1** No Operating Guidance Listed

### **8.2 Maintenance Guidance**

- 8.2.1** Provided it has been reviewed and approved by FWO-MSE, an acceptable program for water treatment may be found in the JCNNM PMI 44-40-004, "Cooling Unit Maintenance and Water Treatment Manual" (Ref. 10.15)

## 9.0 REQUIRED DOCUMENTATION

Maintenance history shall be maintained for by FM for water treatment to include, as a minimum, the parameters listed in the Table 9-1 below:

**Table 9-1 Documentation Parameters**

<b>MAINTENANCE HISTORY DOCUMENTATION PARAMETERS</b>				
<b>PARAMETER</b>	<b>ML 1</b>	<b>ML 2</b>	<b>ML 3</b>	<b>ML 4</b>
<b>Maintenance Activities</b>				
Test Water	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
PM Activities				
<b>Equipment Problems</b>				
Calibrate Instruments	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
Failure Root Cause				
<b>Inspection Results</b>				
Inspection Date				
SSC Condition				

*Basis:* Documentation of the parameters listed in Table 9-1 above satisfies the performance requirements of LPR 230-07-00, Criteria 2, (Ref. 10.5) which states; “Maintenance activities, equipment problems, and inspection and test results are documented.”

A log for each cooling unit shall be maintained as required by the NPDES permit. All maintenance records are subject to NPDES inspection.

### 9.1 Recorded information shall include:

- Date and time
- Structure and location
- Make up and blowdown water meter readings (if meter equipped)
- Make up water conductivity and circulating water conductivity
- Chemical concentrations
- Basin chlorine concentrations
- Chemical level in tank



- Chemical pump speed and stroke
- Cycles of concentration
- Name of person performing tests
- Preventive maintenance performed

**Note:** Records must be kept for a period of 3 years.

*Basis:* NPDES Permit No. NM0028355, Section III, Part 3.

## **10.0 REFERENCES**

The following references, and associated revisions, were used in the development of this document.

- 10.1** LIR 230-05-01.0, Operation and Maintenance Manual.
- 10.2** DOE O 430.1A, Attachment 2 “Contractor Requirements Document” (Paragraph 2, Sections A through C), a requirement of Appendix G of the UC Contract.
- 10.3** DOE Order 433.1, Maintenance Management Program for Nuclear Facilities.
- 10.4** LIR 301-00-02.0, Variances and Exceptions to Laboratory Operation Requirements.
- 10.5** LPR 230-07-00, Maintenance History, Performance Criteria [2].
- 10.6** HACH DO 2000 Spectrophoto Meter Handbook
- 10.7** HACH Water Analysis Handbook
- 10.8** LIR 404-50-01.1, Water Control Pollution
- 10.9** NPDES Permit No. NM0028355
- 10.10** Operations and Maintenance Manual for EPA Category 03A Outfalls
- 10.11** SSS Cooling Unit Maintenance and Water Treatment Manual (PMI 44-40-004)
- 10.12** LA-13171, “The Management of Silica in Los Alamos National Laboratory Tap Water”
- 10.13** Los Alamos National Laboratory Cooling Tower Water Conservation Pilot Study
- 10.14** 20.6.2 3000 NMAC, Permitting and Ground Water Standards, also see DOE Order 5400.1 Environmental Protection
- 10.15** JCNNM PMI-44-40-004, “Cooling Unit Maintenance and Water Treatment Manual”

## **11.0 APPENDICES**

None.